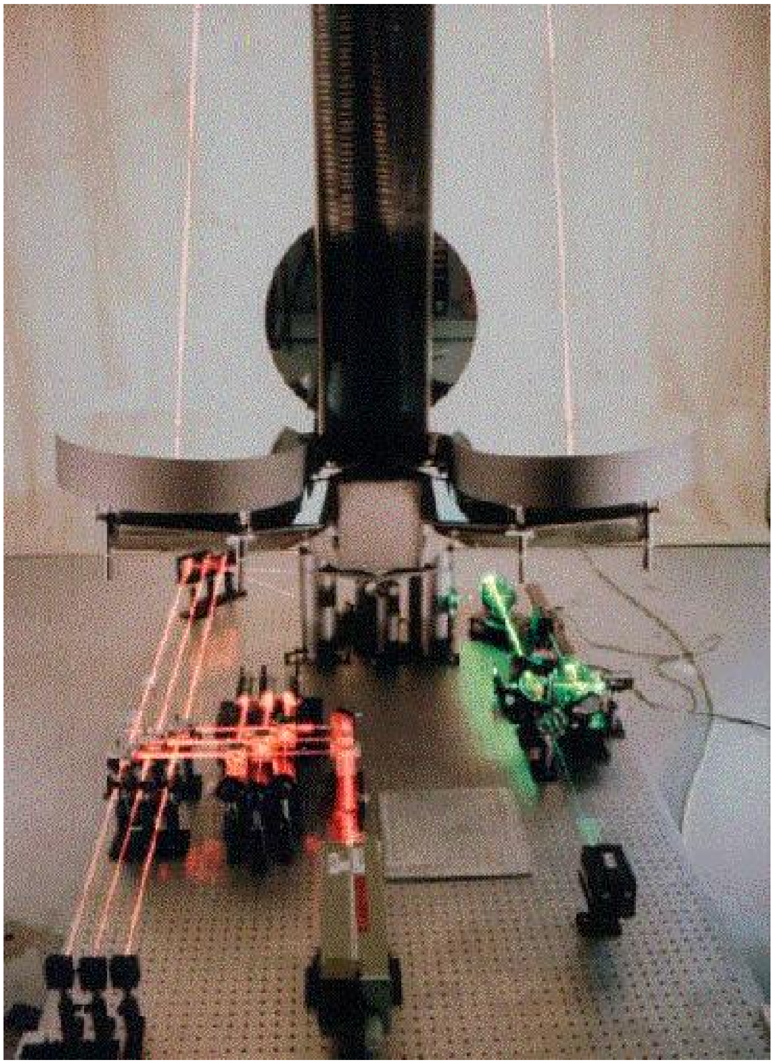
Air Force Research Laboratory | AFRL

Space Vehicles Technology Success Story

Ten-Year Deployable Optical Telescope Program Complete



Payoff

The Deployable Optical Telescope (DOT) ground demonstration enables space-based imaging apertures larger than launch vehicle fairing sizes through multiple segment telescope phasing.

Accomplishment

The last task of phasing multiple large mirror segments on the AFRL Deployable Optical Telescope (DOT) system was completed on 30 September 05 (Figure 1). The brassboard (shown in Figure 2) consists of three deployable 60-cm primary mirror segments and a deployable 3-m secondary mirror tower structure. The advanced control system automatically phases the mirrors from an initial deployment error of over a quarter of an inch to within 8 nanometers or 1/5000th the width of a human hair. Simulated satellite vibrations were also included in the test and were eliminated by the control system. Previous program successes involved phasing smaller 20-cm mirrors using simpler control systems that did not include rejection of simulated satellite vibrations. This final task completes the TRL 5 milestone and is the last AFRL funded activity under this program.

Background

The AFRL Ultra-Lightweight Imaging Technologies Experiment (UltraLITE) program was initiated in 1995 with the purpose of developing technologies vital to the success of future DoD requirements for large space-based optical systems, such as the Space-Based Laser (SBL) system. Current launch vehicle shroud and weight constraints limit the primary mirrors of such systems to less than 5 meters, limiting systems to low earth orbits, which in turn necessitate large, expensive satellite constellations to provide global coverage. The UltraLITE program and DOT experiment provided an integrated ground demonstration of technologies that will allow future optical systems to be stowed for launch, and deployed on-orbit to their operational configuration. Specific technologies that were developed on this program include: lightweight mirror structures, stiffness-critical precision composite structures, advanced control system architectures for autonomous phasing and maintenance, advanced structural dynamic system identification methods and precision mechanisms for deployable space optics applications.

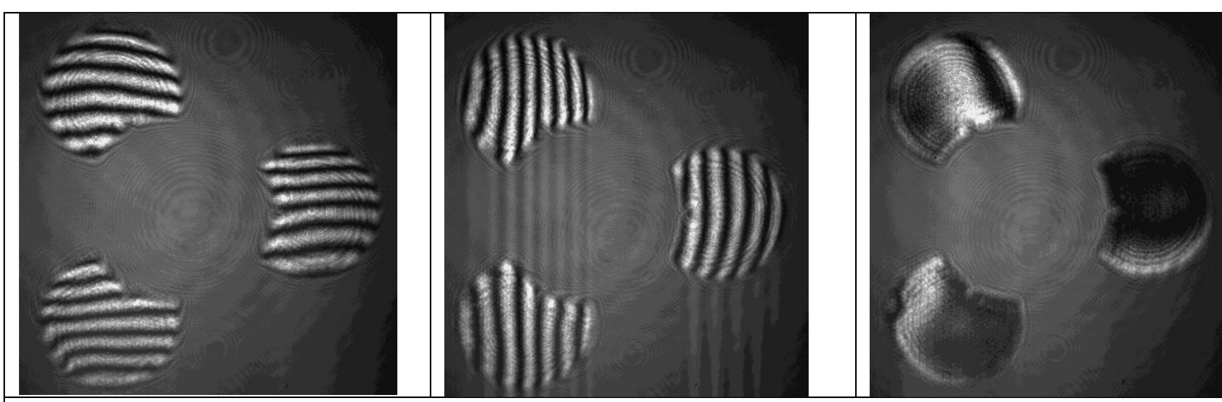


Figure 1, Black and white photographs of DOT primary mirror segments are called the <u>interferograms</u>. The disks are the return light reflected from the mirrors. The stripes on the left and center photos result from the interference of the return light with the reference beam (green Helium-Neon, ~550 nanometer wavelength). The orientation changes as the focus changes. With all three mirrors aligned, the wavefront error is nulled (i.e., the wavefront is continuous across all three apertures), producing the image on the right. The residual error (color variation) on the right results from the very slight radius-of-curvature mismatch between the three mirrors.

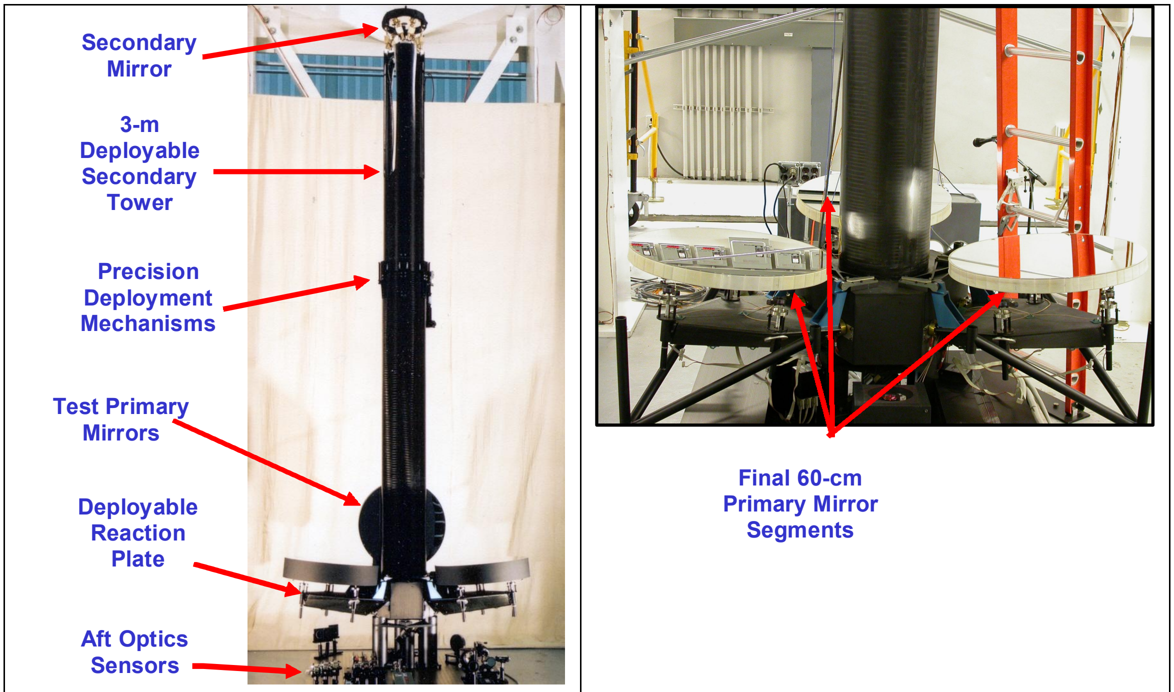


Figure 2. DOT system with (a) test mirrors (b) 60-cm, 12 kg/m^2 final mirrors